Energy Efficiency &
Renewable Energy

Wind Energy Program
Renewable System Interconnection Activities

DOE Collaborative Meeting on
Renewable Systems Interconnection

September 18, 2008

Stan Calvert
Chief Engineer
Wind and Hydro Program

Program Goal

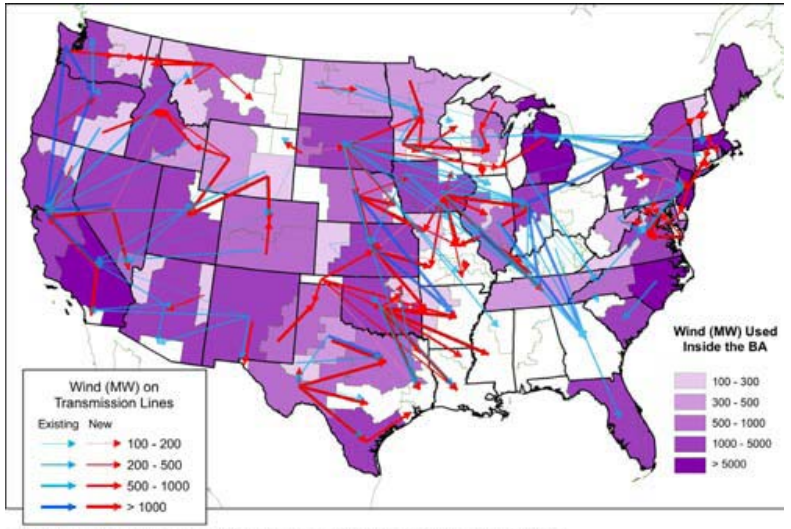
By 2012, complete Program activities addressing electric power market rules, interconnection impacts, operating strategies, and system planning needed for wind energy to compete without disadvantage to serve the Nation's energy needs.

20% Wind Energy by 2030

Energy Efficiency & Renewable Energy

Over 300 GW of wind plant capacity

Report generally indicates where investment in new transmission infrastructure needed

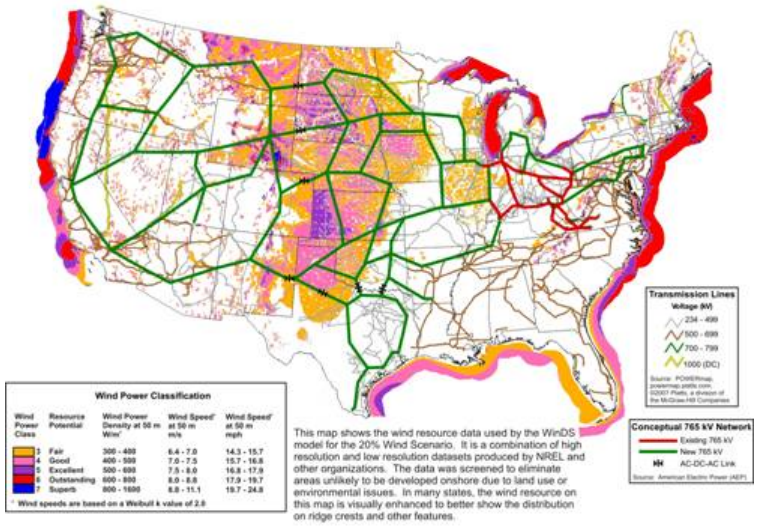


Total Between Balancing Areas Transfer >= 100 MW (all power classes, land-based and offshore) in 2030.
Wind power can be used locally within a Balancing Area (BA), represented by purple shading, or transferred out of the area on new or existing transmission lines, represented by red or blue arrows. Arrows originate and terminate at the centroid of the BA for visualization purposes; they do not represent physical locations of transmission lines.

Also presents conceptual 765 kV EHV overlay examined by AEP

- $60 billion over 20 yrs
- 19,000 mi of line

Delivers additional 200-400 GW



This map shows the wind resource data used by the WinDS model for the 20% Wind Scenario. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.

Program Activity Organization

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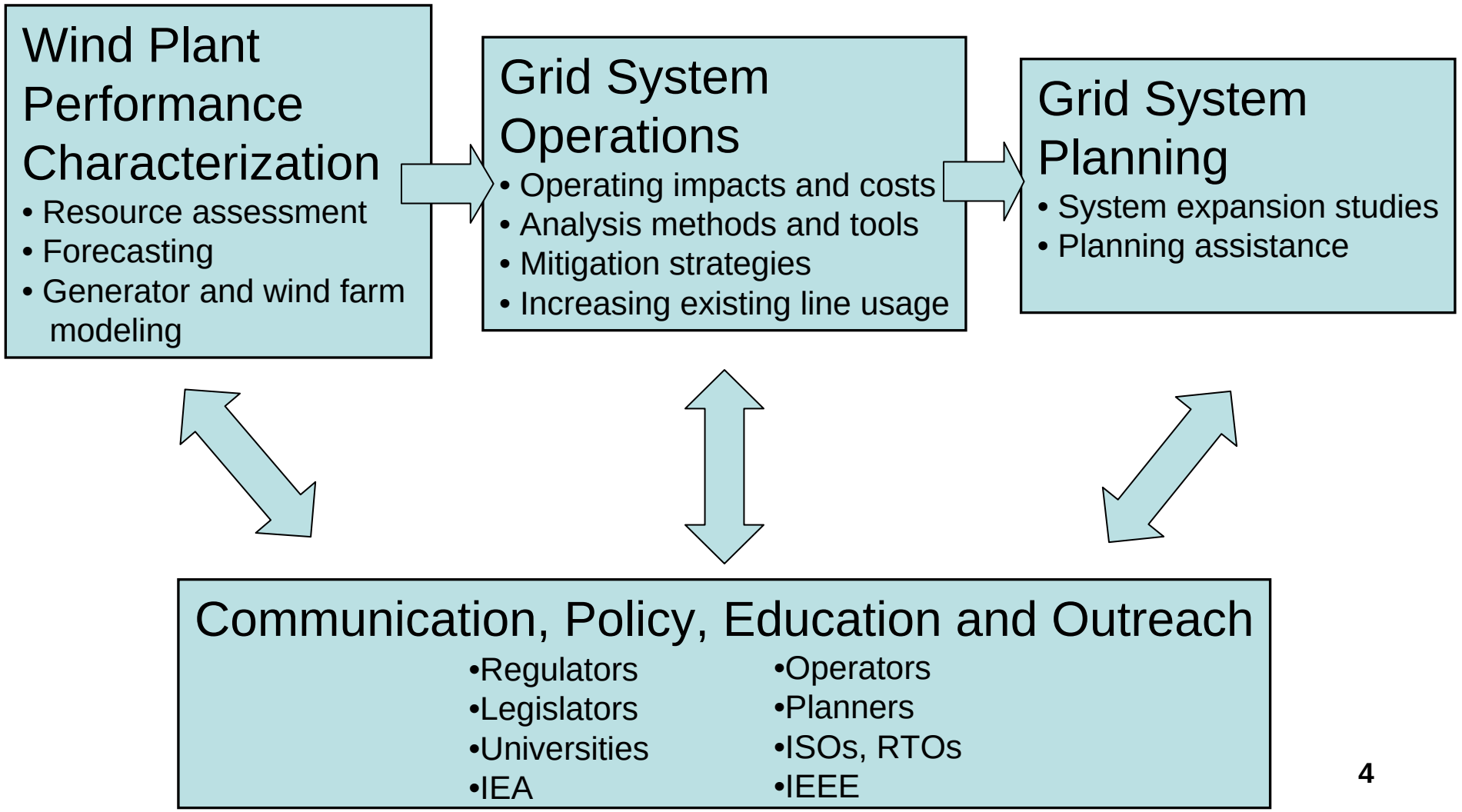

Program Activity Influence

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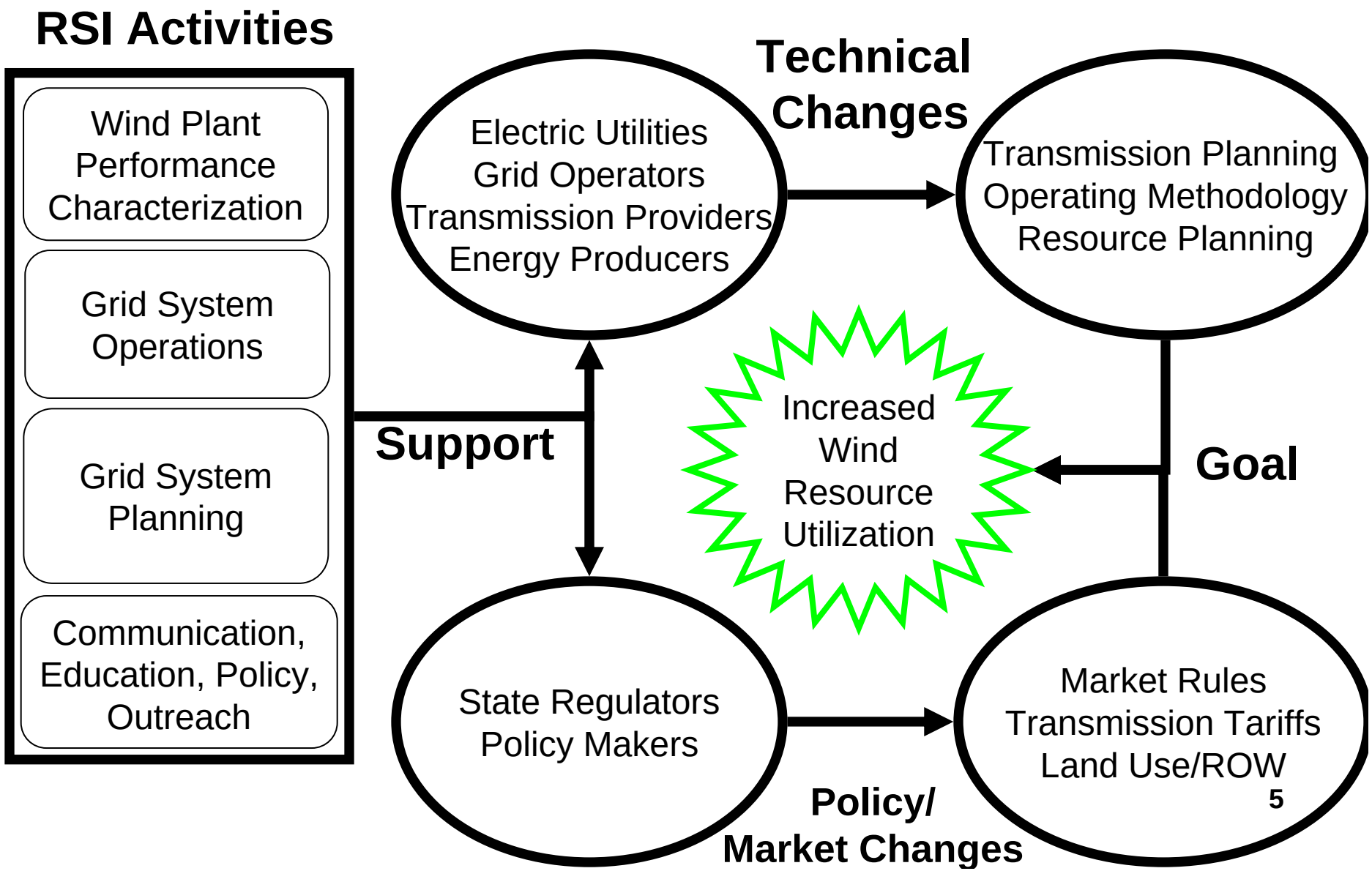


National Laboratory Partners

Energy Efficiency & Renewable Energy

Los Alamos National Laboratory

Sandia National Laboratories

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

U.S. DEPARTMENT OF ENERGY

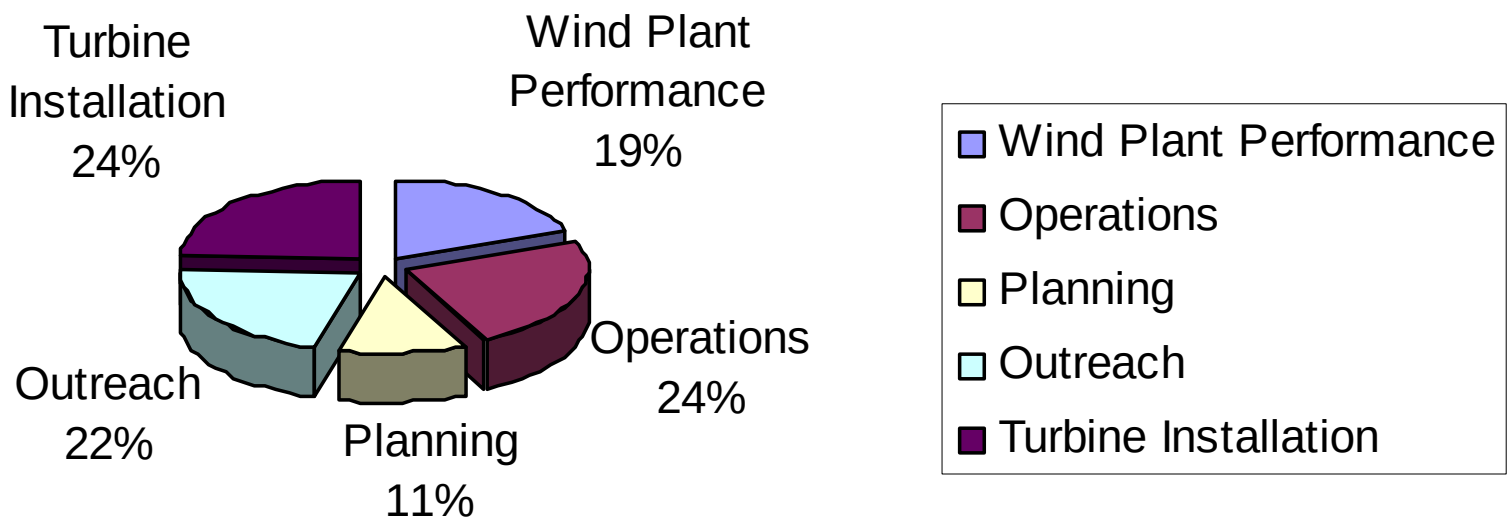
OAK RIDGE NATIONAL LABORATORY

BERKELEY LAB

NREL

Argonne NATIONAL LABORATORY

FY08 Budget Breakout



Total Budget $13.8M

Wind Plant Performance Characterization

Wind Resource

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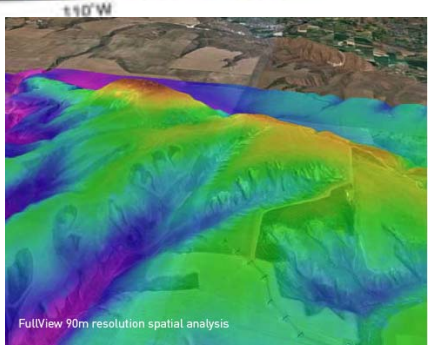
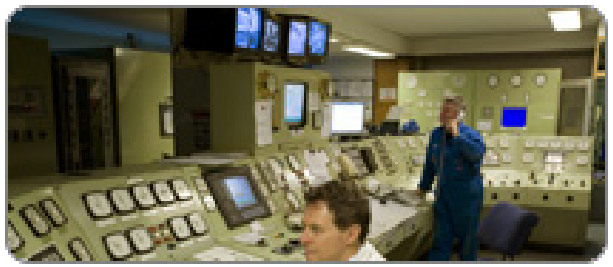
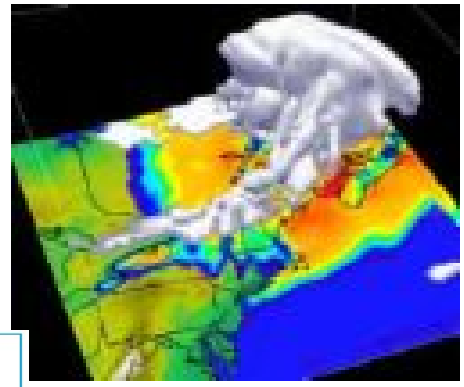
- **Mesoscale wind modeling**
  - Data set for Western Interconnection developed, much of Eastern Interconnection underway
  - 10-minute temporal resolution
  - 2-km spatial resolution
- **Wind Measurements**
  - Tall tower
  - Investigate SODAR
  - Regional wind mapping, meso model validation
- **Forecasting**
  - Improve forecast accuracy on planning, scheduling and system balancing time scales
  - Anticipation of extreme events
- **Database development**
  - Develop comparable solar data
  - Create database of wind and solar 10 min resource data



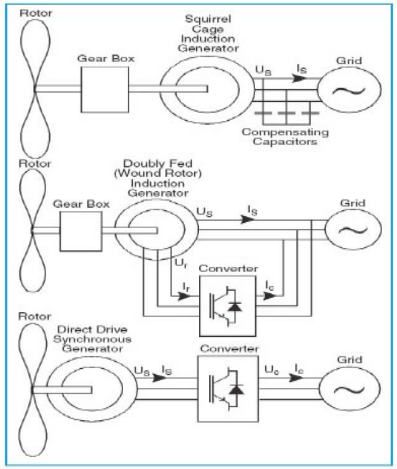
Output Prediction



- **Generator and wind farm modeling**
  - Develop generic non-proprietary generator models for use in integration studies
  - Analyze and model wind farm power characteristics



- **Wind Farm Data Monitoring**
  - Collect and archives high-resolution wind power data from large commercial wind power plants
  - Provides statistics on wind power spatial diversity and correlation, and long-term variability
  - Calibrate and validate wind plant and forecasting models



Grid System Operations and Planning

Timeframes of Interest

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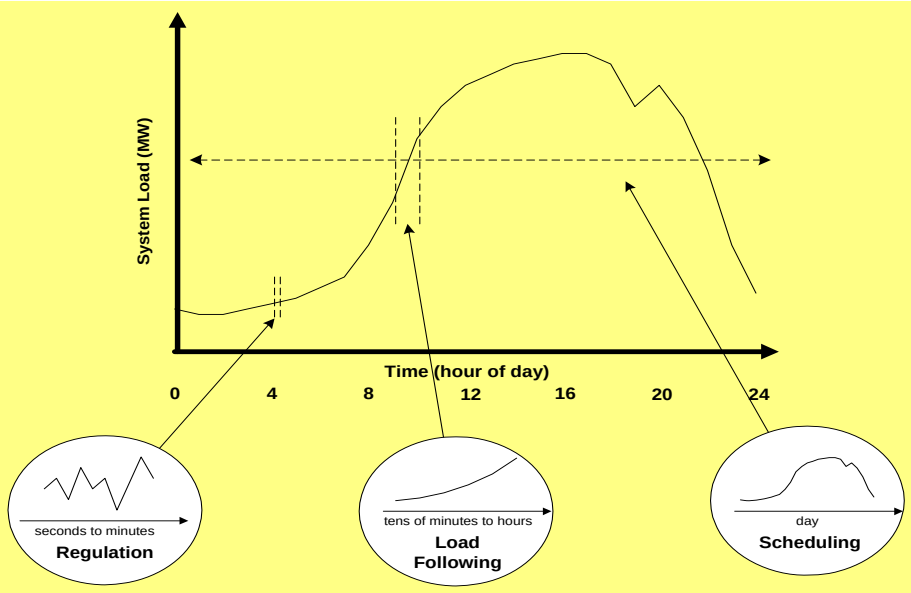

Typical U.S. terminology

- **Regulation-** seconds to a few minutes - System Stability Studies, Operating Procedures (outgrowth of various studies)
- **Load-following-** tens of minutes to a few hours – Production Cost Models
- **Scheduling and unit commitment-** hours to several days – Production Cost Models, Transmission Expansion, and Integration Studies
- **Capacity value-** based on reliability metric (ELCC=effective load carrying capability)-Long-term resource adequacy studies

Grid System Operations

Key Activities

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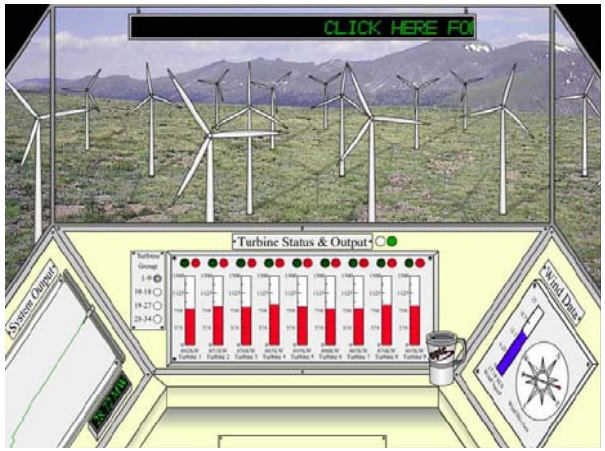
- **Dynamic analysis models**
  - Development and validation for wind energy application
- **Wind integration studies**
  - Quantify impacts of wind on operations, estimate cost of added variability, fault analysis
  - NREL Report on methodologies of integration studies
- **Grid simulators**
  - Develop/apply to prepare grid operators for dealing with sub hourly wind variation
- **Production cost models**
  - Incorporation of stochastic wind modeling
- **Control room use of forecasting**
  - Partner with utilities to develop and evaluate methods for application of advanced forecasting
- **Expanding use of existing lines**
  - Analyze dynamic line ratings, conditional/firm, FACTS, advanced conductors, etc
  - Assess balancing area consolidation, role of market structures (eg ISO/RTO), capacity obligations



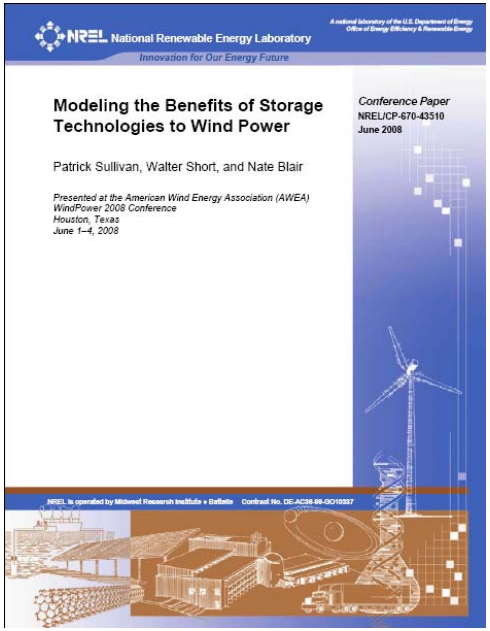
- **NWTC Commercial Turbines**
  - Install state-of-the-art large wind turbines for R&D support of grid system operations challenges

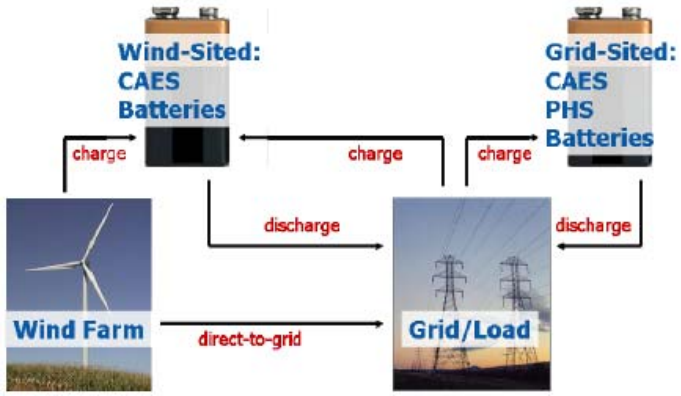
Evaluation of Storage for Wind

- **Recent NREL Study on storage benefits for wind**
  - Based on modeling via ReEDS (formerly WinDS)
  - Evaluated costs, operational merits, and deployment opportunities for energy storage technologies

- **Wind/hydro integration**
  - Analysis and case studies of mitigating wind variability via coordinated operation with hydro assets
  - Collaboration with WAPA, BPA

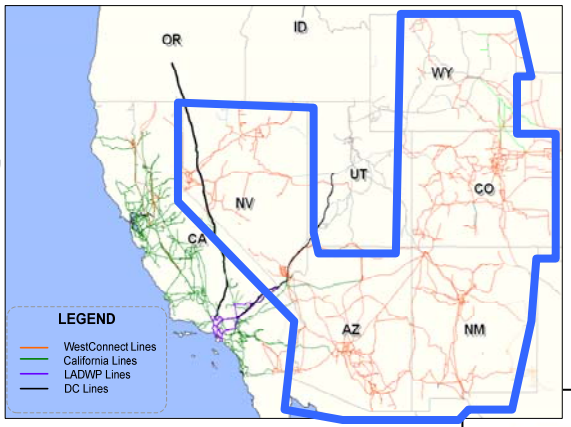
- **Planned study (FY 08 Funding)**
  - Provide quantitative guidance on storage value in high wind penetration grids
  - Examine capacity, energy, and ancillary service values of range of storage technologies in different market structures
  - Characterize current and expected future costs

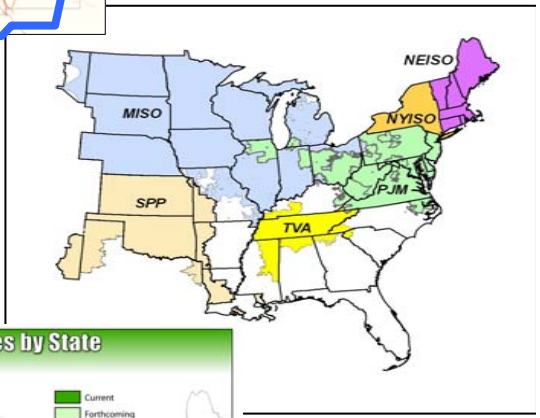


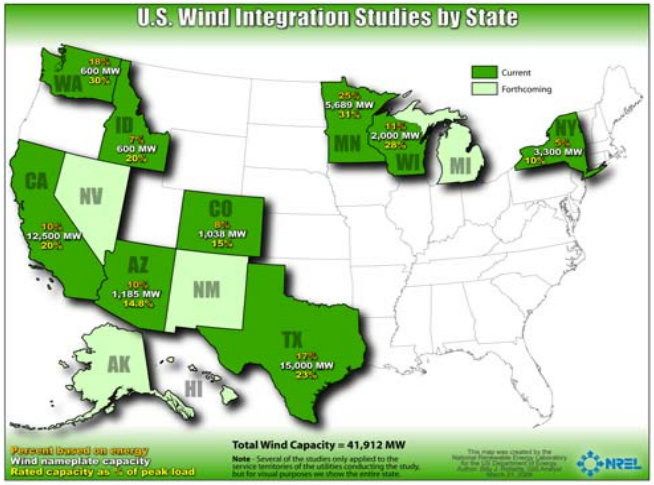


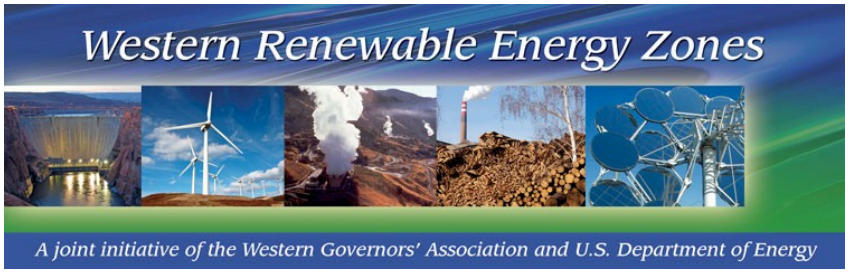
Regional Studies and Assistance

- Western Wind and Solar Integration, Eastern Wind Integration Studies
  - Largest integration studies to date
  - Simulate power system operation and investigate transmission expansion options at wind penetration rates of 20% and 30%
- Northwest Wind Integration Forum
- WECC 15% Renewables Study
- WGA Western Renewable Energy Zone Initiative
- Hawaii Clean Energy Initiative
- Various Smaller Studies for Specific Utilities







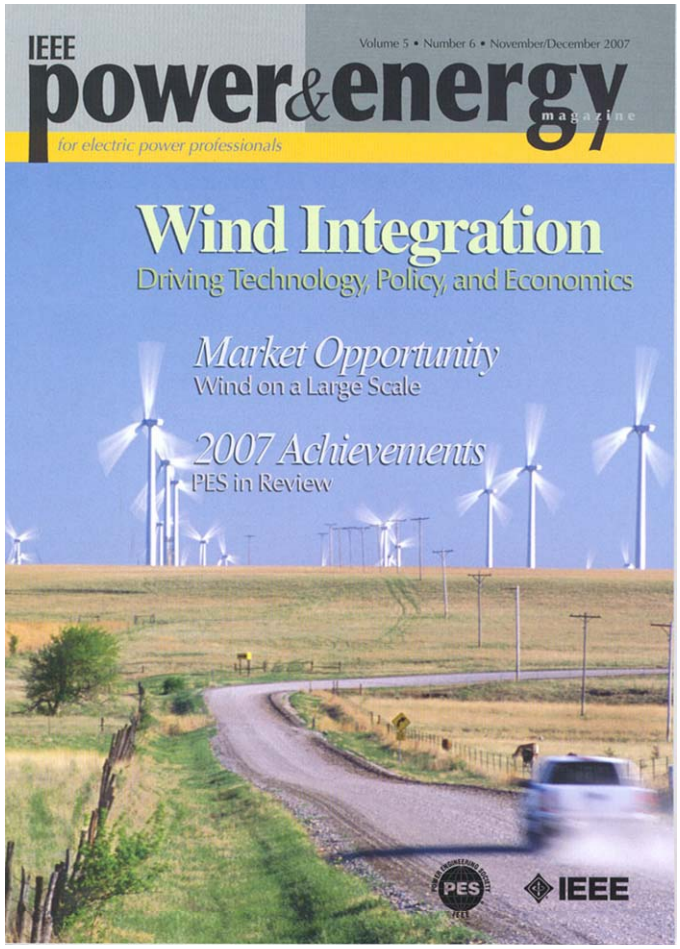


Communication, Policy, Education and Outreach

Key Activities

Energy Efficiency & Renewable Energy

- **Utility Wind Integration Group**
  - Premier technical forum
  - 100+ utility, ISO, and transmission provider members
- **IEEE**
  - Wind Power Coordinating Committee
  - PES Summer meeting Wind Super Sessions
- **NERC**
  - Integration of Variable Generation Task Force standards development



UWIG Utility Wind Integration Group

Accelerating the Integration of Wind Generation into Utility Power Systems

Communication, Policy, Education and Outreach

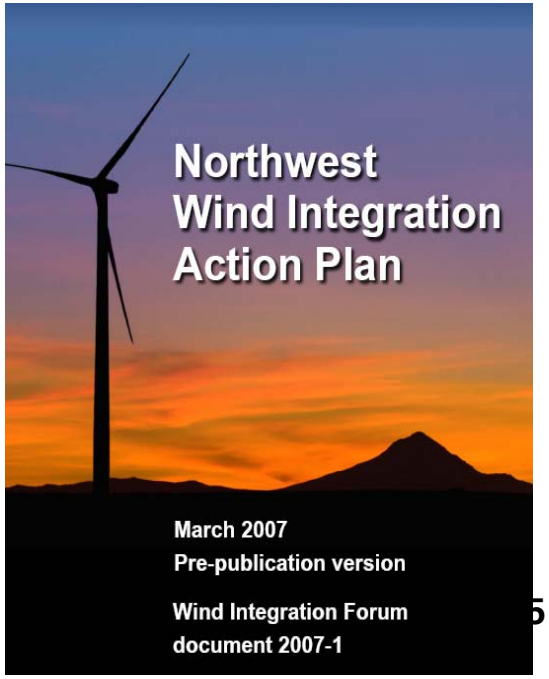
Key Activities (cont)

Energy Efficiency & Renewable Energy

- **IEA**
  - Wind Agreement - high wind penetration and wind/hydro annexes
  - DSM Agreement - distributed renewable integration project

- **NWCC transmission subcommitee**
  - WECC/Upper Midwest/SPP regional engagements

- **Expert team regional issue support**
  - BPA and NWIAF



Communication, Policy, Education and Outreach

Key Activities (cont)

Energy Efficiency & Renewable Energy

- **FERC**
  - 661a LVRT and Var Grid codes, SCADA
  - Order 890: Conditional Firm Transmission
- **PUC/Legislative**
  - Market structure
  - Integration studies, rates, and cost determination
  - Transmission cost allocation and recovery
  - Transmission authorities (RETI, RETA, CO CEDA)
- **Power System Universities**
  - PSERC R&D projects
  - Curriculum development
  - Industry and lab internships
- **Website, presentations, papers, webinars, and conference calls**

Recent/Near-term Developments

Energy Efficiency & Renewable Energy

- **Lab Call July 2008**
  - Solicited Proposals Related to 5 RSI Areas
    - Wind integration analysis and planning
    - Wind energy forecasting methods and applications
    - High-level wind resource assessment and validation
    - Wind integration modeling
    - Wind energy siting studies
  - Project funding awards presented to 7 labs

- **20% Report Roadmap Workshop (Oct 6)**
  - Solicit input from a variety of stakeholders on how to achieve 20% Wind Energy by 2030